

What is claimed is:

1. A method for transpulmonary cooling, comprising the steps of:
providing a liquid having a boiling point of 38 – 300 °C;
5 nebulizing the liquid to form a mist; and
delivering the mist to the airway of a patient so that the patient inhales the mist
to cause systemic cooling.

2. The method of claim 1, wherein the liquid has a boiling point of 38-200 °C.

3. The method of claim 1, wherein the liquid has a boiling point of 38-150 °C.

4. The method of claim 1, wherein the liquid or liquid mist is cooled to below
body temperature before delivery.

5. The method of claim 1, wherein the liquid or liquid mist is cooled to 10 °C or
less before delivery.

6. The method of claim 1, wherein the liquid comprises at least one highly
20 fluorinated compound.

7. The method of claim 6, wherein the at least one highly fluorinated compound
comprises a linear compound.

8. The method of claim 6, wherein the at least one highly fluorinated compound comprises a branched compound.

5 9. The method of claim 6, wherein the at least one highly fluorinated compound comprises a cyclic compound.

10. The method of claim 6, wherein the at least one highly fluorinated compound comprises a saturated compound.

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11. The method of claim 6, wherein the at least one highly fluorinated compound comprises an unsaturated compound.

12. The method of claim 6, wherein the at least one highly fluorinated compound
15 comprises at least one heteroatom.

13. The method of claim 6, wherein the at least one highly fluorinated compound comprises at least one hydrogen.

20 14. The method of claim 6, wherein the highly fluorinated compound comprises at least one halogen.

15. The method of claim 1, wherein the liquid is a fluorocarbon.

16. The method of claim 6, wherein the highly fluorinated compound is a perfluoroalkane of the formula C_nF_{2n+2} .

5 17. The method of claim 16, wherein the perfluoroalkane is perfluorohexane.

18. The method of claim 16, wherein the perfluoroalkane is perfluoroheptane.

19. The method of claim 1, wherein the liquid is a hydrocarbon.

10 20. The method of claim 1, wherein the liquid is a perfluoroether.

21. The method of claim 20, wherein the perfluoroether comprises at least one halogen atom.

15 22. The method of claim 21, wherein the perfluoroether has the formula $C_nF_{2n+1}OC_nF_{2n}Br$.

23. The method of claim 21, wherein the perfluoroether is $CF_3OCF_2CF_2OCF_2Br$.

20 24. The method of claim 21, wherein the perfluoroether is $(BrCF_2OCF_2)_2$.

25. The method of claim 1, wherein the liquid is a hydrofluorocarbon selected from the group consisting of fluorocarbon-hydrocarbon diblocks, fluorocarbon-hydrocarbon ethers, and hydrochlorofluorocarbons.

5 26. The method of claim 1, wherein the liquid is a mixture of fluorocarbons and highly fluorinated compounds.

27. The method of claim 1, wherein the liquid is a hydrofluoroalkane.

10 28. The method of claim 1, wherein the liquid is a hydrochlorofluoroalkane.

29. The method of claim 27, wherein the hydrofluoroalkane is selected from the group consisting of $\text{CF}_3\text{CH}_2\text{F}$, $\text{CF}_3\text{CHFCH}_3$, and $\text{CF}_3\text{CF}_2\text{CF}_2\text{H}$.

15 30. The method of claim 1, wherein the liquid mist further comprises at least one fluorinated component.

31. The method of claim 30, wherein the at least one fluorinated component boils below 37°C .

20 32. The method of claim 1, wherein the liquid mist further comprises at least one component that boils below 37°C .

33. The method of claim 32, wherein the at least one component is SF₆.

34. The method of claim 32, wherein the at least one component is He.

5 35. The method of claim 32, wherein the at least one component is CO₂.

36. The method of claim 30, wherein the at least one fluorinated component is a light fluorocarbon or a hydrofluorocarbon.

10 37. The method of claim 30, wherein the at least one fluorinated component is a hydrofluoroalkane with a boiling point below 37 °C.

38. The method of claim 30, wherein the at least one fluorinated component is perfluoropentane.

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39. The method of claim 30, wherein the at least one fluorinated component is selected from the group consisting of perfluorobutane, perfluorocyclobutane, perfluoropropane, C₃F₇Br, and perfluorotetrahydropyrene.

20 40. The method of claim 30, wherein the at least one fluorinated component is a light fluorinated ether with a boiling point below 37°C.

41. The method of claim 40, wherein the light fluorinated ether is selected from the group consisting of $C_3F_7OC_2F_5$ and $(C_2F_5)_2O$.

5 42. The method of claim 1, wherein the liquid has a boiling point of 38 – 80 °C.

43. The method of claim 1, wherein the liquid has a boiling point of 40 – 75 °C.

44. The method of claim 1, wherein the liquid has a boiling point of 38 – 75 °C.

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45. The method of claim 1, wherein the liquid has a boiling point of 50 – 70 °C.

46. The method of claim 1, wherein the liquid has a boiling point of 38– 70 °C.

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47. The method of claim 1, wherein the liquid is perfluorocyclohexane.

48. The method of claim 20, wherein the perfluoroether is selected from the group consisting of $(C_3F_7)_2O$, $CF_3(OCF_2)_3OCF_3$, $(CF_3OCF_2CF_2)_2O$ and $(CF_2CF_2CF_2CF(C_4F_9)O)$, $(iso-C_3F_7)_2O$, and $C_4F_9OC_2F_5$.

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49. The method of claim 20, wherein the perfluoroether is $(C_3F_7)_2O$.

50. The method of claim 20, wherein the perfluoroether is $(CF_3OCF_2CF_2)_2O$.

51. The method of claim 20, wherein the perfluoroether is $\text{CF}_3(\text{OCF}_2)_3\text{OCF}_3$.

52. The method of claim 1, wherein the liquid is selected from the group
5 consisting of perfluoro(n-butyl)tetrahydrofurane, perfluoro-2-(n-butyl)tetrahydrofurane, and
perfluoro-3-(n-butyl)tetrahydrofurane.

53. The method of claim 1, wherein the liquid is a hydrofluoroether.

10 54. The method of claim 53, wherein the hydrofluoroether is selected from the
group consisting of $\text{C}_4\text{F}_9\text{OCH}_3$ and $\text{C}_4\text{F}_9\text{OC}_2\text{H}_5$.

55. The method of claim 1, wherein the liquid is the hydrofluoroether $\text{C}_4\text{F}_9\text{OCH}_3$.

15 56. The method of claim 1, wherein the liquid is the hydrofluoroether $\text{C}_4\text{F}_9\text{OC}_2\text{H}_5$.

57. The method of claim 32, wherein the hydrochlorofluoroalkane is
selected from the group consisting of $\text{CH}_2\text{ClCF}_2\text{Cl}$ and $\text{CHCl}_2\text{CHF}_2$.

20 58. The method of claim 1, wherein the mist droplets range in size from 0.1
– 100 microns.

59. The method of claim 1, wherein the mist droplets range in size from 1 – 5
microns.

60. The method of claim 1, wherein the mist droplets range in size from 2 – 4
5 microns.

61. The method of claim 1, wherein the volume of liquid administered ranges from
0.1 to 20 liters.

10 62. The method of claim 1, wherein the volume of liquid administered ranges from
2 to 6 liters.

63. The method of claim 1, wherein administration of the liquid is continued until
the systemic temperature is reduced to at least 34 °C.

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64. A composition for transpulmonary cooling, comprising:
a nebulized liquid in the form of a mist, the liquid having a boiling point of 38
– 300 °C.

20 65. The composition of claim 64, wherein the liquid has a boiling point range of 38
- 150 °C.

66. The composition of claim 64, wherein the mist droplets range in size from 0.1 - 100 microns.

67. The composition of claim 64, wherein the liquid or liquid mist is cooled to 5 below body temperature before delivery.

68. The composition of claim 64, wherein the liquid or liquid mist is cooled to 10 °C or less before delivery.

10 69. The composition of claim 64, wherein the liquid is a highly fluorinated compound.

70. The composition of claim 69, wherein the highly fluorinated compound comprises a branched compound.

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71. The composition of claim 69, wherein the highly fluorinated compound comprises a cyclic compound.

72. The composition of claim 69, wherein the highly fluorinated compound 20 comprises a saturated compound.

73. The composition of claim 69, wherein the highly fluorinated compound comprises an unsaturated compound.

74. The composition of claim 73, wherein the highly fluorinated compound comprises at least one heteroatom.

5 75. The composition of claim 73, wherein the highly fluorinated compound comprises at least one hydrogen.

76. The composition of claim 73, wherein the highly fluorinated compound comprises at least one halogen.

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77. The composition of claim 64, wherein the liquid is a fluorocarbon.

78. The composition of claim 64, wherein the liquid is a mixture of highly fluorinated compounds or fluorocarbons.

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79. The composition of claim 64, wherein the liquid has a boiling point of 38 – 150 °C.

80. The composition of claim 64, wherein the liquid has a boiling point of 38 – 80 °C.

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81. The composition of claim 64, wherein the liquid has a boiling point of 38 – 75 °C.

82. The composition of claim 64, wherein the liquid has a boiling point of 40 – 75 °C.

83. The composition of claim 64, wherein the liquid has a boiling point of 38 – 70 °C.

84. The composition of claim 64, wherein the liquid has a boiling point of 50 – 70 °C.

85. The composition of claim 64, wherein the liquid is perfluorohexane.

85. The composition of claim 64, wherein the liquid is perfluorocyclohexane.

86. The composition of claim 64, wherein the liquid is a perfluoroether.

87. The composition of claim 86, wherein the perfluoroether is selected from the group consisting of. $(C_3F_7)_2O$, $CF_3(OCF_2)_3OCF_3$, $(CF_3OCF_2CF_2)_2O$ and $(CF_2CF_2CF_2CF(C_4F_9)O)$, $(iso-C_3F_7)_2O$, and $C_4F_9OC_2F_5$.

88. The composition of claim 86, wherein the perfluoroether is $C_3F_7-O-C_3F_7$.

89. The composition of claim 64, wherein the liquid is perfluorodiglyme.

5 90. The composition of claim 64, wherein the liquid is $CF_3(OCF_2)_3OCF_3$.

91. The composition of claim 64, wherein the liquid is $C_4F_9OCH_3$.

92. The composition of claim 64, wherein the liquid is $C_4F_9OC_2H_5$.

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93. The composition of claim 64, wherein the liquid is selected from the group consisting of perfluoro(n-butyl)tetrahydrofurane, perfluoro-2-(n-butyl)tetrahydrofurane, and perfluoro-3-(n-butyl)tetrahydrofurane.

15 94. The composition of claim 64, wherein the liquid is a hydrofluoroether.

95. The composition of claim 94, wherein the hydrofluoroether is selected from the group consisting of $C_4F_9OCH_3$ and $C_4F_9OC_2H_5$.

20 96. The composition of claim 94, wherein the hydrofluoroether is $C_4F_9OCH_3$.

97. The composition of claim 94, wherein the hydrofluoroether is $C_4F_9OC_2H_5$.

98. The composition of claim 64, wherein the liquid is a hydrochlorofluoroalkane.

99. The composition of claim 64, wherein the liquid further comprises a hydrochlorofluoroalkane selected from the group consisting of $\text{CH}_2\text{ClCF}_2\text{Cl}$ and $\text{CHCl}_2\text{CHF}_2$.

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100. The composition of claim 64, wherein the mist droplets range in size from 0.1 – 100 microns.

101. The composition of claim 64, wherein the mist droplets range in size from 1 – 5 microns.

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102. The composition of claim 64, wherein the mist droplets range in size from 2 - 4 microns.

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103. The composition of claim 102, wherein the liquid further comprises at least one component that boils below 37 °C.

104. The composition of claim 103, wherein the at least one component is SF_6 .

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105. The composition of claim 103, wherein the at least one component is He.

106. The composition of claim 103, wherein the at least one component is CO_2 .

107. The composition of claim 103, wherein the at least one component is fluorinated.

108. The composition of claim 107, wherein the at least one component is a
5 hydrofluoroalkane.

109. The composition of claim 107, wherein the at least one fluorinated component is perfluoropentane.

10 110. The composition of claim 107, wherein the at least one fluorinated component is selected from the group consisting of perfluorobutane, perfluorocyclobutane, perfluoropropane, perfluorotetrahydropyrane.

111. The composition of claim 107, wherein the at least one fluorinated component
15 is selected from the group consisting of $C_3F_7OC_3F_5$ and $(C_2F_5)_2O$.

112. A medical device for transpulmonary cooling, comprising:
an inhaler device; and
a nebulized liquid in the form of a mist the liquid having a boiling point of 38
20 – 300 °C.

113. The medical device of claim 112, wherein the liquid or liquid mist is cooled to below body temperature before delivery.

114. The medical device of claim 112, wherein the liquid or liquid mist is cooled to 10 °C or less before delivery.

5 115. The medical device of claim 112, wherein the liquid is a highly fluorinated compound.

116. The medical device of claim 115, wherein the highly fluorinated compound comprises a branched compound.

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117. The medical device of claim 115, wherein the highly fluorinated compound comprises a cyclic compound.

118. The medical device of claim 115, wherein the highly fluorinated compound
15 comprises a saturated compound.

119. The medical device of claim 115, wherein the highly fluorinated compound comprises an unsaturated compound.

20 120. The medical device of claim 119, wherein the highly fluorinated compound comprises at least one heteroatom.

121. The medical device of claim 119, wherein the highly fluorinated compound comprises at least one hydrogen.

122. The medical device of claim 119, wherein the highly fluorinated compound
5 comprises at least one halogen.

123. The medical device of claim 112, wherein the liquid is a fluorocarbon.

124. The medical device of claim 112, wherein the liquid is a mixture of
10 fluorocarbons.

125. The medical device of claim 112, wherein the liquid has a boiling point of 38 –
150 °C.

126. The medical device of claim 112, wherein the liquid has a boiling point of 38 –
15 80 °C.

127. The medical device of claim 112, wherein the liquid has a boiling point of 40 –
75 °C.

128. The medical device of claim 112, wherein the liquid has a boiling point of 38 -
20 70 °C.

129. The medical device of claim 112, wherein the liquid has a boiling point of 50 – 70 °C.

5 130. The medical device of claim 112, wherein the liquid is perfluorohexane.

131. The medical device of claim 112, wherein the liquid is perfluorocyclohexane.

132. The medical device of claim 112, wherein the liquid is a perfluoroether.

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133. The medical device of claim 132, wherein the perfluoroether is selected from the group consisting of. $(C_3F_7)_2O$, $CF_3(OCF_2)_3OCF_3$, $(CF_3OCF_2CF_2)_2O$ and $(CF_2CF_2CF_2CF(C_4F_9)O)$, $(iso-C_3F_7)_2O$, and $C_4F_9OC_2F_5$.

15 134. The medical device of claim 112, wherein the liquid is $C_3F_7-O-C_3F_7$.

135. The medical device of claim 112, wherein the liquid is perfluorodiglyme $((CF_3OCF_2CF_2)_2O)$.

20 136. The medical device of claim 112, wherein the liquid is $CF_3(OCF_2)_3OCF_3$.

137. The medical device of claim 112, wherein the liquid is $C_4F_9OCH_3$.

138. The medical device of claim 112, wherein the liquid is $C_4F_9OC_2H_5$.

139. The medical device of claim 112, wherein the liquid is selected from the group consisting of perfluoro(n-butyl)tetrahydrofurane, perfluoro-2-(n-butyl)tetrahydrofurane, and
5 perfluoro-3-(n-butyl)tetrahydrofurane.

140. The medical device of claim 112, wherein the liquid is a hydrofluoroether.

141. The medical device of claim 140, wherein the hydrofluoroether is selected
10 from the group consisting of $C_4F_9OCH_3$ and $C_4F_9OC_2H_5$.

142. The medical device of claim 140, wherein the hydrofluoroether is $C_4F_9OCH_3$.

143. The medical device of claim 140, wherein the hydrofluoroether is $C_4F_9OC_2H_5$.

144. The medical device of claim 112, wherein the liquid is a
15 hydrochlorofluoroalkane.

145. The medical device of claim 112, wherein the liquid further comprises a
20 hydrochlorofluoroalkane selected from the group consisting of CH_2ClCF_2Cl and $CHCl_2CHF_2$.

146. The medical device of claim 112, wherein the mist droplets range in size from
about 0.1 – 100 microns.

147. The medical device of claim 112, wherein the mist droplets range in size from 1 – 5 microns.

5 148. The method of claim 6, further comprising the step of recovering the at least one highly fluorinated compound.

149. The method of claim 148, further comprising the step of recirculating the at least one highly fluorinated compound.

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150. A method for transpulmonary cooling, comprising the steps of:

providing a liquid fluorocarbon;

nebulizing the liquid to form a mist;

delivering the mist to the airway of a patient so that the patient inhales the mist

15 to cause systemic cooling;

recovering the fluorocarbon from an expired gas; and

recirculating the recovered fluorocarbon to the patient.

151. The method of claim 150, wherein the step of recirculating the recovered
20 fluorocarbon to the patient comprises the steps of:

nebulizing the recovered fluorocarbon to form a mist; and

delivering the mist to the airway of a patient so that the patient inhales the mist to cause systemic cooling.